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1941 CROP INCOME AND EXPENSE ON SELECTED TUNG ORCHARDS

Economic and Credit Research Division
in cooperation with the
Land Bank Division
Farm Credit Administration
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FOREWORD

The Farm Credit Administration is interested in the extension of credit to any agricultural enterprise which is able to support sound loans. The Farm Credit Administration has always recognized the production of tung nuts as an agricultural enterprise. Until 1943, however, tung production has been regarded as an enterprise in which the ability to repay the original investment with interest, to provide a margin for the retirement of debt, and at the same time to provide the operator a reasonable level of living, was not yet demonstrated with sufficient conclusiveness to justify extension of long-term credit in this field.

Studies made by the Farm Credit Administration in 1935 and in 1941[1] indicated the need for more information regarding the long-term earning power of land devoted to tung trees. Extreme variations in soil characteristics, in systems of management used, in degree of care exercised, and in production attained from year to year all justified in the conclusion that "production represents the major uncertainty facing tung growers." Most of the findings and conclusions of these earlier studies continue to hold true at the present writing. On the other hand, as the years go by, more and more tung orchards are coming into bearing, natural factors are weeding out orchards improperly located and poorly cared for, and growers and research workers are accumulating a body of experience upon which increasing dependence can be placed in anticipating future yields and returns.

In response to renewed requests by representatives of the tung industry asking the extension of credit, and in recognition of the increased importance of tung oil to American industry in the present war emergency, a re-examination of the industry was conducted in the late fall of 1942. The present report is based upon the results of this recent examination, which had as its major objective the determination of yields and 1941 crop operating costs on well-cared-for tung orchards of bearing age.

In addition to reporting yields and operating costs for the group of selected tung orchards, there is ventured a forecast of future net earnings for the same orchards.

For the benefit of persons who may be unfamiliar with tung production, a general description of the tree and its proper care and a list of selected references have been added.

[1]Some results of a study of the tung-oil industry in the United States. Farm Credit Administration (mimeographed) 54 pages. May 1935. The tung oil situation. Farm Credit Administration (mimeographed) 25 pages. September 1941.

1941 CROP INCOME AND EXPENSE ON SELECTED TUNG ORCHARDS*

by

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SUMMARY

In most of the tung belt where conditions are favorable, it appears that a capable grower with a bearing age orchard can expect an average of about 3 1/2 crops in 5 years. The virtually complete loss of 1 year's crop and the reduction in another year's crop is to be expected from an occasional late spring frost destroying the crop in the bloom stage. Crop yields have been much less than those anticipated in the early days of promotion of the industry in the United States. Location of many orchards on poorly adapted soil and topography, failure to use only seed or planting stock of known high-producing parentage, and lack of adequate care after planting have been the chief factors contributing to this unfortunate situation. On the other hand, the relatively uncommon instances in which the factors were all favorable have indicated that average annual yields over a 5- or 10-year period of three-fourths to 1 ton per acre are possible.

It is expected that the market price of tung oil in the United States will average not over 13 1/2 cents per pound, with a price to farmers of about $38 per ton for nuts delivered to the mills, over a period of years after world conditions have settled back to something like "normal." In the

*NOTE: This report was prepared in the Economic and Credit Research Division. Acknowledgment is made to the Land Bank Division for assistance in planning the survey, in providing transportation, and in editorial review of the manuscript. Appreciation is expressed to workers in the college agricultural experiment stations and tung oil research laboratories of Louisiana, Mississippi, Alabama, Georgia, and Florida, as well as to the tung growers, for essential data and many helpful observations.

same post-war period it is expected that average costs on bearing age orchards, which in 1941 were about $15 per acre for production and about $8.50 per ton for harvesting, will approach $13 per acre for production and $4.00 per ton for harvesting. These costs include depreciation as well as all immediate cash costs, but exclude interest on investment and wages for the owner's labor or management. Under such conditions, well-cared-for, properly located orchards of good original stock with average annual yields of three-fourths to 1 ton per acre should net their owners from $10 to $20 per acre; these figures, however, exclude interest on investment and any wages for the owner's labor or management.

Tung orchards should be located within the tung belt only on fine sandy loam or sandy loam soils of such series as Orangeburg and Norfolk. The soil must be well drained, with adequate slope for air drainage, and so located as to be free from frequent frost injury. Proper care includes the use of at least one properly fertilized leguminous cover crop, with supplemental fertilizer for the tung trees. In addition to turning under the cover crops at the most advantageous times, cultivation should be adequate to keep down all growth which might compete with the tung trees for moisture and plant food.

SCOPE AND METHOD

The objective of this study has been to determine as accurately as possible the yields over a period of years and the 1941 crop operating costs on well-cared-for tung orchards[1] of bearing age. As a matter of common knowledge, many tung orchards are in the abandonment stage and obviously would not support long-term loans on the basis of any reasonable standards. Neglected orchards were carefully excluded from the study; tung orchards included in the sample were limited to ones which were generally recognized by the industry itself as outstanding examples of good management and successful operation. The group selected demonstrates fairly well the practical possibilities of tung production when the orchards are cared for according to the knowledge attained to date.

Certain records were retained in the group despite possible exaggeration of cost, both as a means of illustrating possible wide variations in actual cost and also as a means of injecting conservatism into final averages. As finally developed for complete tabulation, there were adequate schedules on 20 tung enterprises, distributed as follows by States:

Mississippi	7
Louisiana	5
Florida	4
Alabama	3
Georgia	1

[1]While the term "grove" is used about as frequently as the term "orchard" throughout the tung producing area, the term "orchard" is preferred by most technical workers in the field and is perhaps more indicative of the degree of care now regarded as necessary for successful tung production.

The number of records is too small to provide averages which might be considered typical of any particular State; the data will not be presented by States for that reason.

Data on yield, production costs, and cultural practices were obtained through personal interviews in the field directly with the owner or manager who actively supervised the operations. Crop yield data were not yet available for the 1942 crop except as estimates, but were obtained for the 1941 crop and for each of as many previous crops as the operator's memory or records would provide with reasonable certainty. Reported yields were checked with mill records whenever feasible.

Production costs were obtained for the 1941 crop season, this being the most recent complete season including harvesting. The costs here presented specifically exclude any charge for interest on the original investment or any compensation to the operator for any actual labor contributed to the tung enterprise by the operator. As a matter of fact, most of these operators did not put any actual physical labor into the enterprise themselves, but exercised general supervision over the enterprise. However, four of the operators did put their own physical labor into the operations to the extent that, if valued at what it would have cost them to hire additional labor to do the work which they themselves did, it would have cost from $2 to $15 per acre additional.

This study excludes developmental cost, such as the price of the raw land, cost of breaking and preparing the ground, and cost of planting and caring for trees before bearing age is reached. Production costs were often incurred and almost universally calculated by the operators on a per acre basis, whereas harvesting costs were computed on a per ton basis. This general practice will be observed in this report. Production costs are here further separated into three groups: Labor and machinery, fertilizer and cover-crop seed, and other production costs.

Expense for repairs and depreciation on machinery was included in labor and machinery cost, whereas similar expense on buildings was included in "Other" costs. The "Other" costs classification also includes such items as taxes, insurance, sacks used in harvesting, fencing material, telephone and postage expense connected with the tung enterprise, and farm organization dues.

The full importance of recently adopted improved practices had not yet been demonstrated by the time of this survey in many cases. It appeared to be true that most operators were still in the process of determining the cultural practices which they would follow consistently; for such operators some compromises in estimated costs were made to provide for the difference in practice upon which the operator had most recently decided.

The methods used in estimating future yield, price, and cost are detailed in the section on probable future income and costs.

1941 CROP INCOME AND COSTS

Probably few agricultural enterprises can boast a wider diversity of types of operators and systems of management. Orchards included in the study range from 20 to over 5,000 acres; types of operators range from owners of small specialized tung orchards to operators providing contract care for large corporate holdings. Despite the high degree of individualism in operators and methods of operation, as well as occasional instances of probable error or exaggeration, total production costs per acre or harvesting cost per ton showed a strong tendency to approach a median figure.

Table 1 summarizes the net result of the tung operations for the 1941 crop season for the 20 operators. Gross income averaged more than $26 per acre and total cost, including harvesting, averaged more than $17 per acre, with the net average income of $8.55 per acre. However, the net income figure as shown on individual records varied from a loss of $24.01 to a net gain of $63.17 per acre. Nine operators showed a profit on tung, while 11 operators showed a loss.

TABLE 1 - Total costs and income per acre summarized for 20 selected tung orchards, 1941 crop season

Item	Amount per acre		
	Range	Median	Average
Total cost[a]	$ 9.83- 41.74	$15.80	$17.49
Income[b]	0.68-102.30	13.85	26.04
Net return[c]	-24.01- 63.17	-1.62	8.55

[a] Includes harvesting and depreciation expense but excludes interest on investment and wages for the owner's physical labor, if any.

[b] From tung enterprise only. Low amounts per acre due to low yield or to high proportion of young trees, or both.

[c] From tung enterprise only. Eleven operators also had additional farm income from nontung enterprises ranging up to $20 per acre.

Yields were below those anticipated in the early days of the promotion of the tung industry. About three and one-half crops out of 5 years seemed to be the long-time average possibility, due to the hazard of spring frosts. Yields were extremely variable between orchards and between years on the same orchards; 1941 yields varied from less than 100 pounds of nuts per acre to more than 1 1/2 tons per acre. The 1941 crop per acre was less than 500 pounds for 8 orchards, from 500 to 1,500 pounds for 8 orchards, and more than 1,500 pounds for 4 orchards.

Of the 11 orchards showing a loss in table 1, even at current high prices for the tung nuts, at least 8 could be explained primarily on the grounds

of immaturity of the trees, since a considerable portion of the trees were below bearing age and often those of bearing age were only in their fourth to seventh season.

A poorly drained subsoil accounts for the loss on another of these currently unprofitable orchards despite heavy expenditures for care and fertilizer. Unusual frost injury accounts for another orchard. The other may be explained on the grounds of a combination of immaturity and inadequate care. Some of these, also, are influenced by the relative degree of fertility inherent in the soil. However, this factor was less of a consideration in this sample than would be the case if one were to consider all orchards found in an area, for the reason, as before stated, that the sample was hand-picked in advance to represent the better orchards.

Two of the orchards showing a loss on tung production nevertheless exhibited a net income on all operations as a result of other farm income from livestock or crops. Altogether, 11 out of the 17 tung operators received other farm income in addition to that provided by the tung enterprise. Usually this other income took the form of a pasture fee for livestock allowed to graze in the grove for a portion of the year, or the sale of calves and the increased inventory of breeding stock belonging to the operator.

Table 2 presents the summarized cost believed to be typical of better-cared-for tung orchards under 1941 crop and labor conditions. Labor

TABLE 2 - Production and harvesting costs on 20 selected tung orchards, 1941 crop season

Group of costs[a]	Amount		
	Range	Median	Average[b]
Production costs, per acre:			
Labor and machinery	$3.77-14.90	$ 7.84	$ 8.49
Fertilizer and cover-crop seed	0.00- 8.00	4.30	4.22
Other production costs	0.21- 5.65	1.98	2.24
Total up to harvesting	$9.15-26.70	$13.64	$14.95
Harvesting costs, per ton:	$4.50-18.50	$ 8.00	$ 8.45

[a]No charge is made for interest on investment nor for operator's physical labor, if any.

[b]Unweighted.

and machinery costs per acre varied from $3.77 to $14.90, with a median of $7.84 per acre. It is reasonable to suppose this figure was affected by efficiency in the use of labor and machinery, and by the nature and extent of the cultural operation of farms. One orchard in Mississippi received only one disking a year, whereas one in Alabama had as many as seven; likewise, considerable variation existed in the extent to which cover crops were used. The number of records, however, are insufficient to make it possible to assign anything like exact valuations to the effect of these several factors on the labor and machinery costs figures.

Likewise, fertilizer and cover-crop seed expense was subject to variations in prices paid and amounts used. One orchard which formerly had received considerable amounts of fertilizer and cover cropping was currently getting none whatever. At the other extreme was an orchard in Mississippi for which fertilizer and cover-crop seed expense apparently totaled $8.00 an acre. The median cost was $4.30 an acre - approximately the same as the simple average of $4.22.

Other production costs per acre range from a low of 21 cents (primarily for taxes) to a high of $5.65 per acre, with a median of $1.98 and simple average of $2.24 . Combining all costs up to harvest showed a range in cost per acre from $9.15 to $26.70, with a median of $13.64 and an average of $14.95. Harvesting cost per ton varied according to the level of wages in a particular area, the extent to which the ground under the tree was free of weeds and briars, the amount of extra cost in special cases for hauling to storage or to the mill, and to some extent according to the relative quantity produced per acre. The simple average of harvesting costs was $8.45 per ton with the median at $8.00.

Some Factors Affecting Costs

While the number of records is not sufficient to permit detailed analysis nor to give confidence in the precise accuracy of such relationships as are demonstrated, nevertheless, it is possible to show in a general way the influence that certain factors have upon various elements entering into the total cost.

For example, it might be expected that those orchards which comprise the larger acreages would make somewhat more efficient use of labor, machinery, and some other expense items.

Table 3 shows our 20 records sorted in three groups according to the acreage in tung trees, without regard to the portion of the orchard presently bearing or nonbearing. It is indicated here that costs per acre, up to harvesting, are significantly higher for orchards with the smaller acreages than for the larger orchards. Considering that the relationship shows up despite the fact that no other factors are held constant, it would seem conservative to conclude from this table that operators of acreages of 1,000 or more acres of tung could care for their orchards for

about $2.50 an acre less than could operators of less than 150 acres. On the other hand, some of this apparent saving in cost in the past may have been due to less adequate care on extensive plantings. Also, a resident farmer with a diversified farm would have an opportunity to spread certain fixed costs over other operations and avoid certain overhead costs which large corporate organizations must bear.

TABLE 3 - Production costs per acre of 20 selected tung orchards grouped according to total acreage in tung, 1941 crop season[a]

Group range in acreage of tung[b]	Number of records	Average cost per acre
Less than 150	8	$16.48
200-700	6	13.96
1,000 or more	6	13.89

[a]Up to harvesting; excludes interest on investment and return for operator's labor.

[b]The study did not include any orchards having acreages within the ranges omitted in this table.

Harvesting costs include the amounts paid to the crew which picks up the nuts off the ground under the trees and puts them into sacks or baskets, hauling the nuts to a farm shed or storage; cost of storage if the operator had to rent storage space; and cost of hauling to the mill if this cost was not absorbed by the mill operator who bought the nuts. The cost of first gathering the nuts off the ground is the largest element of this harvesting cost and usually was paid at a fairly uniform rate per basket or sack picked up. Some variation in this rate occurred, however, both because of local labor conditions and because of differences in the ease with which the nuts could be picked up. Where the crop lay thick under the tree, it was, of course, much easier and faster to get the crop gathered up and could be expected to be reflected to some extent in the rate. Also, there is some relationship between the crop production per acre and the cleanliness of the spots under the trees where the nuts fall, as the consequence of improved care in the way of increased cultivation or mowing and clearing away of weeds under the trees, or as an indirect result of size, vigor, and amount of shade cast by the trees. Consequently, some relationship might be expected between the crop yield per acre and the cost of harvesting per ton. In table 4 our 20 records are grouped according to the 1941 production per bearing acre. The simple average harvesting cost per ton for the 10 orchards which produced in 1941 less than a quarter of a ton per acre was nearly $10 per ton, whereas the 6 orchards which produced one-half ton or more per acre got the harvesting done for less than $7 per ton. Inadequate production is doubly serious since low production results in high harvesting costs per unit accompanied at the same time by low gross income per acre.

TABLE 4 - Harvesting costs per ton related to rate of production per acre, 20 selected tung orchards, 1941 crop season

Group range in yield of 1941 crop, pounds per acre	Number of records	Average harvesting cost per ton
Less than 500	10	$9.86
500-999	4	7.80
1,000 or more	6	6.53

Of course, it is impossible to reduce the combined effects of location, soil, and adequacy of care to a single statistical measure in this study. Nevertheless, a very crude approximation can be had by examining the records in relation to the number of times that the orchard received a tillage operation. This tillage operation may have been light or heavy, but in a very rough way does give an idea of the degree of care put into the management of the orchard. Thus, for example, certain large orchards which were managed in an extensive manner with a minimum of care were usually the orchards which received very few diskings. In table 5 the records have been grouped according to the number of times the orchard was cultivated or disked.

Cost per acre for labor and machinery went up as the number of times cultivated increased. Total cost per acre up to harvesting increased at a somewhat faster rate than did labor and machinery costs, thus lending some weight to the point that usually increased cultivation indicates better care, more fertilizer, and cover crops. It should not be inferred that a greater number of diskings necessarily indicates wiser or more successful care, or that simply by more cultivation production can be increased to a point of profitability.

The records were also examined for any possible relationship between the number of tillage operations and the production per acre, either in terms of the best record made to date on the acreage bearing, or in terms of the production per acre which might reasonably be expected in the future. No dependable relationship could be discovered in this respect. This fact is due, it is believed, to the great variation between orchards in the natural fertility and drainage of the soil, and to the previous history of care given the orchards. Incidentally, this might be a good place to make the observation that during the course of the survey no evidence was uncovered which would indicate that an orchard which has previously been badly neglected can ever be brought to the same stage of profitable production that is possible for an orchard of equal age which has received good care from the start. It remains to be proven whether or not a neglected orchard can nevertheless be restored to some measure of profitable production. There were not enough orchards of this type included in the study to give any indication.

TABLE 5 - Number of times orchards received some tillage operation, in relation to certain costs per acre, 20 selected orchards, 1941 crop season

Number of times cultivated, disked, or plowed	Number of records	Average cost per acre	
		Labor and machinery	Total production costs[a]
1 or 2	6	$7.69	$13.24
3 or 4	10	8.20	14.84
5 to 7	4	9.86	17.76

[a]Excluding harvesting.

PROBABLE FUTURE INCOME AND COSTS

The report would be incomplete without some attempt to project into the future the yield, cost, and net return that might be expected of these orchards in the light of probable trends in wages and prices, and the increased yields to result from improved care and from normal growth of of the trees.

Probable future production per acre was estimated after taking into account a considerable number of factors. Foremost among these factors was the actual production record of the orchard over a period of years. To this consideration was added that of the general suitability of the soil on which the orchard was located for the production of tung in light of its native fertility, water drainage (particularly in the subsoil), and topographical location. Some weight also was given to the effect which the grower's most recent cover-crop and fertilizer program and his system of cultivation might have over a period of years. Arriving at a specific figure for probable future production was, of necessity, influenced by personal judgment. Nevertheless, a determined effort was made to be consistent and conservative in the application of the various factors.

Table 6 summarizes in a general way the factors considered in arriving at estimates of future production per acre. Values given therein are not to be taken as absolute, nor as indicating any precise weighting between factors. Rather the process of establishing these values was the simple one of ranking the particular factor - for example, soil - according to relative degrees of desirability.

To illustrate the process by which these estimates were made, take the case of the second record listed in the second section of table 6. Exact figures will not be given in order to avoid violating the confidential understanding of the survey. This is an orchard of between 300 and 400 acres. In both the 1940 and 1941 crop seasons, the bearing portion of

TABLE 6 - Some relative values used in estimating probable future average production per acre of tung nuts, 20 selected tung orchards; based on 1942 survey data

Past production average of bearing orchard[a]	Acres of bearing age trees in percent of total	Age of bearing trees in 1941[b]	Suitability of soil, drainage, and climate	Degree of care		Expectation for future averages	
				Cover crops and fertilizer	Cultivation - No. of times[c]	Production per acre	Net income per acre
		(years)				*(pounds)*	*Average*
High	72	15	Excellent	Fair[d]	2)		
High	71	12	Good	Good	4)	2,000	$17.47
High	72	6 and 7	Excellent	Excellent	4)		
High	100	10 to 13	Fair	Good	4)		
High	79	5 to 7	Good	Excellent	3)		
Medium	14	9 to 12	Excellent	Excellent	4)		
Medium	100	8	Good	Excellent	2)	1,500	
Medium	65	8 to 11	Good	Excellent	5)	to	11.48
Medium	52	4 to 7	Excellent	Excellent	4)	1,999	
Medium	82	8 to 9	Good	Good	2)		
Low	67	5	Excellent	Excellent	6)		
Low	100	7	Good	Fair	1)		
Medium	39	Mostly 16	Excellent	Good	7)		
Medium	74	4 to 6	Fair	Good	2)	1,000	
Low	76	5 to 7	Fair	Excellent	3)	to	5.98
Low	56	4 to 6	Fair	Poor	3)	1,499	
Low	100	4 to 5	Fair	Good	2)		
Low	41	4 to 6	Fair	Good	3)		
Medium	100	14 to 17	Poor	Excellent	3)	Less than	-7.24
Low	100	10 to 12	Poor	Excellent	5)	1,000	

[a] Low = less than 500 lbs.; Medium = 500-999 lbs.; High = 1,000 lbs. or more.

[b] Years in place in the orchard. Does not count time in nursery before setting in the orchard.

[c] Plowed, disked, or harrowed.

[d] Formerly excellent.

this orchard produced well over 1,000 pounds per acre on trees which for the most part were at the end of only their sixth growing season in place in the orchard. Since growers are constantly learning new facts about which soils are most suitable for tung, it is reasonable to suppose that the nonbearing portion of this orchard will do at least as well as the older trees planted before much was known about the proper selection of soil. A small portion of this orchard has been planted on Caddo soil, which is definitely not suited to tung production. The orchard also has illustrated what is currently accepted as excellent practice with respect to care. Two cover crops a year were grown and turned under to add nitrogen and humus to the soil. Disking in the summertime was governed by the necessity of keeping down weeds. Significant amounts of basic slag and of mixed fertilizer also were applied. On the basis of all these factors and others, what is believed to be a conservative estimate of future annual average production of 1,500 pounds per acre was assigned to this orchard.

On the basis of this procedure and considering a 5- or 10-year period, it has been estimated that 2 of these 20 orchards will never produce more than an average of 700 pounds per acre; that 7 will probably produce from 1,000 to almost 1,500 pounds per acre; that 8 will produce from three-quarters of a ton to nearly a ton to the acre; and that 3 probably will produce a ton or more to the acre. Optimistic champions of the tung industry probably will at once challenge the low proportion of high yield estimates for this select group of 20 producers. Nevertheless, it seems likely that these estimates are as high as may conservatively be expected as average yields, taking into consideration the probable frequency of late spring frosts, together with possibly an occasional early fall freeze. Tung crops have given some indication of a tendency toward an "alternate bearing" habit; however, it is not yet clear to what extent this may be due to a lack of balance between the trees' requirements and the soil fertility.

Making allowances for shifts in costs and prices, as will be explained hereafter, the expected average net income per acre in relation to production is shown by groups in the last column of table 6. The expected net income per acre rises with the expected production per acre but at a faster rate, from a loss of more than $7 per acre to a high (group average) of over $17 net profit per acre.[1]

No one knows, of course, what the long-time average price of tung oil will be after the war. Prior to the war the price of tung oil fluctuated very widely and rapidly, more or less in response to arrivals of oil from China, formerly our principal source. Since China has been and undoubtedly will continue in normal times to be by far the major source of our supply, it is probable that with the resumption of more normal trade conditions after the war, prices for tung oil will return to something like pre-war levels.

[1]Before paying interest on investment, or wages to the owner-operator.

In past years, the price of tung oil per pound in drums at New York has fluctuated widely from a low of 5.5 cents per pound in December 1932,[1] to a current fixed ceiling of 39 cents. The simple average of monthly prices for the 11 years 1929 to 1939, inclusive, was 12.4 cents per pound.[2] Fifteen cents per pound seems to be the lowest figure considered possible by the majority of the growers interviewed. For the purpose of estimating future income, the arbitrary figure of 13.5 cents per pound has been selected, having in mind the following considerations:

1. Operating in the direction of a sustained price will be,

   (a) a probable shortage of commercial shipping space for a number of years after the war;

   (b) increased demands for tung oil to go into new uses have been, are being, and will be, discovered as its virtues become more widely known; and

   (c) the probable boom in the business of the principal customer for tung oil, the paint industry, as the consequence of civilians catching up on long-neglected repairs.

2. Operating in the direction of lowering prices will be,

   (a) restoration of prewar volume of imports into this country from China, both as a consequence of normal trade and also probably to be stimulated by reciprocal trade agreements between the United States and China;

   (b) competition from other natural oils for some of the uses to which tung oil is put; and

   (c) the threat or actual presence of tung oil substitutes which are even now being manufactured on a commercial scale and which conceivably could vastly expand in a post-war period when equipment for new physical facilities can be more easily acquired and when business enterprises will be actively seeking new enterprises to develop.

While the average yield of oil obtained by the expeller type presses now in use has averaged only 16 percent of the weight of all air-dried whole nuts crushed by the mills, the percentage of oil extracted from the crops of our selected better operators has normally run 17 percent or more. The oil content appears to run higher in well-cared-for, high producing

[1] From data compiled by Bureau of Agricultural Economics as quoted in "The Tung Oil Situation," September 1941, confidential report of the Farm Credit Administration, U.S.D.A.

[2] During this same period, the index of prices received by farmers for all agricultural products (August 1909-July 1914 = 100) averaged 101.4 calculated on a calendar year basis and 99.3 calculated with the years beginning in July. From "Agricultural Statistics" for 1941, table 688, page 556.

orchards than in neglected and low yielding orchards. Therefore, a 17 percent yield is entirely conservative for the type of orchards under consideration. Using these figures for percentage of oil recovered and for the price of oil on the market results in a value at the mill based on salable oil extracted of $45.90 per ton of nuts. From this figure must be subtracted the operating cost and profit for the crushing mill, which up to the present time has varied from about $8.00 to $15.00 per ton. Here again, dynamic factors will be at work tending to reduce the cost of crushing. Among these will be the development of cooperative crushing mills, increased knowledge and skill in handling the nuts delivered so as to crush the nuts at the optimum moisture point, competition between millers for crops on the basis of minimum service cost, and technological improvements in the methods of extraction including the strong possibility of development of solvent extraction plants. The arbitrary mill cost of $7.90 per ton is, therefore, deemed ample, and this figure subtracted from our calculated value of the nuts gives a price returnable to the farmer of $38.00 per ton.[1]

About two-thirds of the tung growers interviewed were of the opinion that they could continue to operate at a profit, even should the farm price for tung nuts drop to $35 to $40 per ton. In most instances it has been the practice of the miller to buy the nuts at the farmer's storage shed for a flat figure per ton and for the hauling cost to be absorbed by the purchaser. As quality and moisture standards become workable, standardized, and more widely known and adopted, growers of high quality nuts may expect some premium. It is here assumed that the payment will be made solely on the basis of the oil which can be extracted and sold.

It is reasonable to suppose also that with a general return of oil prices toward more normal levels, production costs will also undergo some decline. From observations made during the course of this survey, it is believed that present labor and machinery costs are from one-third to one-half higher than pre-war, and that present fertilizer and cover-crop seed expenses are up from 15 to 25 percent. It is conservatively estimated that over a considerable period of years, the growers may expect a decline in labor and machinery costs per acre of 20 percent from present levels and in the fertilizer and cover-crop seed expense of 10 percent. Other production costs up to harvesting may decline somewhat, but

[1]Substantially the same farm value per ton may be derived in a number of ways, for example: (a) by altering the factors used in the direction of a lower oil content, a higher price for oil, and a higher charge for the mill; or (b) by using a higher oil content, a lower price for oil, and a lower charge for the mill. It is also possible, of course, to get considerably different results by manipulating the figures. It is believed that the $38 figure is supported by enough reasonable presumptions to serve our purpose here.

No credit has been given here to the fact the tung meal (expeller cake) and hulls had an approximate value in 1942 as fertilizer amounting to $4 to $6 per ton of whole nuts as delivered at certain mills. The chemical composition of tung meal indicates a content of 4 to 6 percent nitrogen, 1 to 2 percent phosphoric acid, and about 1 percent potash. The market for tung meal or press cake did not appear to be widespread or well established, however. It seems likely that this amount may be reduced or absorbed completely by post-war declines in prices of fertilizer materials, by probable future adjustments in oil mill charges when the mill operator does not retain the press cake for his own use, and by general increased use of fertilizer on tung orchards perhaps balancing the residual value of the meal as fertilizer for the grower's tung orchard.

due to the inclusion of rather stable elements such as taxes, no reduction is forecast for this class of costs. Harvesting costs per ton are expected to come down eventually 25 percent from 1941 levels. These forecasts have been applied to the actual costs reported by the growers to anticipate the cost that these growers may have in the future.

The expected production of each grower has been multiplied by the arbitrary value of $38 per ton to get the gross value of the tonnage produced. The combined effect of all these projections is shown in table 7.

TABLE 7 - Probable costs and income under "normal" post-war conditions expected, 20 selected tung orchard operators..

Item	Range	Median	Simple average
Cost per area:			
Production:			
Labor and machinery[a]	$3.02 to 11.92	$5.78	$6.78
Fertilizer and cover-crop seed[b]	0.00 to 7.20	3.86	3.80
Other items[c]	0.21 to 5.65	1.98	2.24
Total production	$7.78 to $23.11	11.64	$12.82
Harvesting[d]	1.48 to 7.50	4.00	4.08
Total cost per acre	$11.78 to $30.61	$15.79	$16.90
Value of crop per acre[e]	9.50 to 38.00	28.50	25.48
Net return per acre	$-11.31 to $23.43	$ 8.88	$ 8.58

[a] 20 percent below 1941 cost.

[b] 10 percent below 1941 cost.

[c] Same as 1941 cost.

[d] 25 percent below 1941 cost per ton, multiplied by expected production in tons per acre.

[e] Expected production per acre (in tons) multiplied by $38.00.

Simple averages of all operators show an expected total cost per acre up to harvesting of $12.82, of which about $7.00 is for labor and machinery, about $4.00 for fertilizer and cover-crop seed, and about $2.00 for other costs. Harvesting costs, expected to average about $6.34 per ton for this group of operators would amount to $4.08 per acre since production is not expected to average as high as a ton per acre. The net income per acre on the tung enterprise for the 20 operators is expected to average about $8.58 over a period of years. It may come to mind that this figure is only slightly different from the simple average of net returns realized on the 1941 operations. This similarity is due to the fact that high incomes being realized currently will be reduced by declining prices, while present low earnings will be boosted in several instances by increases in production and by reduction in unit costs.

Before leaving the question of the future possibilities for these selected growers in particular, and for the tung producers in general, a further observation should be made. The foregoing estimates have been made on a conservative basis, and it is entirely possible that actual developments would make the picture brighter than it is painted here. Probably the best of these operators approach the possibilities to be expected in the future. One reason for optimism is that with some encouragement and direction given to the industry, a greater degree of uniformity in practices and costs may be expected. This should bring about an optimum in health and productive capacity of the orchards, at the same time that care and cost of care are held to a reasonable minimum consistent with the results desired. Few, if any, of these growers have been giving their orchards too much care; others certainly have been giving them not enough. The cost of production for some of the larger orchards as given here necessarily has included items for office expense, overhead salaries, and perhaps other items which would not enter into the picture for a so-called "dirt farmer." Again, it has been shown with reasonable certainity that the use of fertilizer and cover crops in adequate amounts can be expected to increase both the total quantity of oil and the extractable percentage of oil in the crop over that to be found in crops from orchards which lack such treatment. Thus while the mill-run-average percentage of oil extracted from the whole fruit delivered to the mills has consistently averaged about 16 percent for the entire industry, nevertheless, practically every one of the selected growers interviewed had generally obtained at least 17 percent, and often about 18 percent. With the likely development of solvent extraction mills after the war, it is entirely probable 98 percent of the total oil in the nut will be recovered. The total oil in the nut for well-cared-for orchards commonly runs as high as 21 to 25 percent of the whole air-dried fruit. Furthermore, it should be pointed out that the records which have been used necessarily are based on plantings which for the most part were made before much was known about the possibilities of seed selection, and before satisfactory techniques for budding and grafting had been worked out and widely used.[1] With the development of superior strains and the greater dissemination of high quality budded stock of known parentage, the normal rates of production should go up to a much higher level than those commonly found at present.

The growers interviewed and the orchards which they operated were about as varied in background and in results as are individual dairy cows. Take, for example, the previous experience or the background of the operators. Only four had had any considerable farm experience before getting into tung production. Other operators had been and to a considerable extent still were interested in such diverse enterprises as lumbering, contracting, manufacturing, merchandising, the practice of medicine or law, advertising, real estate sales, etc. Only six of the operators were in any appreciable degree dependent upon their tung enterprise for their livelihood.

[1]Budded stock is available only to a limited extent at present, and the very promising results from its use have been obtained largely under semilaboratory conditions not duplicating field conditions on an extensive basis.

While many of these operators control large acreages, nevertheless, the opinion was frequently expressed that the future of the industry lay with the smaller operators, and particularly the general farmers who might well include tung as one of their enterprises, at least to the extent of fence row or barnyard plantings, or small orchards of 5 or 10 acres. Where soil and climatic conditions are favorable, this idea has much to recommend it.

Very few of the operators were in favor of any form of Government subsidy to the industry. Some were interested in the possibility of tariff protection in the event that Chinese tung oil ever forced the American price to unbearably low levels. The assistance given by the soil conserving and building payments made by the Agricultural Adjustment Administration has been a lifesaver to a considerable number of the operators, and has encouraged better care than would otherwise have been given to their orchards; these payments have been quite valuable also in the direction of publicizing the value of soil fertility, and an intelligent fertilizer and cover-crop program.

Most of the operators were in no need of additional credit at the present time. Several indicated that they could have used credit in an earlier period when tung fruit was not selling for its present high prices. If such credit had been available, it would have been used for the development of additional acreage of tung, primarily, and to a lesser extent would have been used for improved care. There is some demand at present for capital to develop additional acreage and to refinance existing debts.

DESCRIPTION OF THE TUNG TREE AND ITS PROPER CARE

The intention here is to give a general picture of what tung oil and its uses are, what the trees look like, where it can be expected to grow successfully, and some general recommendations with respect to proper care. It is by no means to be inferred that this discussion attempts to be either final or complete but only to summarize what appears to be the consensus of current opinion as to adequate care. Extensive information is available both through publications of the State colleges of agriculture and through correspondence with the excellent tung oil research laboratories which have been established in the area at Bogalusa, Louisiana; Fairhope, Alabama; Cairo, Georgia; and Gainesville, Florida. The research workers at these laboratories are constantly discovering new and more authoritative facts about the proper propagation and care of the tung trees, but already much is known and accepted which would prove of immense value if put to practice in the area generally.

Tung oil is a viscous pale yellow or light amber liquid with a slight odor similar to that of linseed oil. The oil contains a high percent of glyceride of eleostearic acid. It is highly prized for use in paints, varnish, the manufacture of linoleum of all types, and many other products because of its property of rapidly drying to form a tough, elastic, wrinkle-free film which is highly impervious to moisture and resistant to

the action of mildew and mold. While it has been used for many decades in China, it has been only within fairly recent times that tung oil has become recognized widely in this country.

The tree belongs to the Spurge family, for which the Latin name is Euphorbiaceae, and to the Genus Aleurites. The particular kind which is grown to the almost complete exclusion of other species in this country is Aleurites Fordi. It is a deciduous tree with large dark green leaves usually shaped approximately like a heart, but often with three more or less distinct lobes, particularly on young trees. Under favorable conditions it is a fast-growing tree which usually attains a height of 20 to 25 feet and a spread of about the same distance or slightly more. Certain very old trees have grown to considerably larger size. The tree requires at least a short cool season with a suggestion of frost to help throw it into complete dormancy and thereby make it more resistant to cold winter weather. Climatically it is adapted to an area approximately bounded on the south by Ocala in Marion County, Florida, and on the north, at the present time, by an imaginary temperature line indicating not more than 30 frost days per year. It may be that later experimental work will develop varieties adapted to colder temperatures. Roughly speaking, the tung oil belt is in an area about 100 miles wide north and south, extending eastward across the southern Gulf States from near the eastern boundary of Texas into Georgia and possibly South Carolina.

Before the leaves come out in the spring, the trees bloom with a profusion of white flowers with pink centers. Pollination is no problem since both male and female elements appear on the same tree and the tree is probably to a large extent self-pollinated. The fruit consists of a variable number of kernels, usually three to seven, triangular in shape and enclosed by a thin hard shell about the size of a small pecan. These shells are in turn enclosed in a fibrous cortex. The whole fruit is about the size of a small apple. As the season progresses, the fruit changes from an olive green to a rich mahogany or cordovan leather red to a final brown or almost black. When mature, the nuts fall to the ground where they are allowed to lie until they have dried sufficiently so that they will keep in storage without heating or spoiling.

The productive life of the tree is as yet a somewhat uncertain matter in this country, but various estimates have placed it at 30 to 50 years. Certain old trees experimentally planted about 35 years ago are still bearing large crops. Indications are that the best productive age of the trees may be from their tenth to twentieth years. To date no serious insect or disease pest or similar difficulties have arisen. No spraying and little pruning are required. Because of the tree's early-blooming habit, late spring frosts are one of the greatest hazards and tung orchards located where late spring frosts occur frequently will not be profitable because too many crops will be destroyed or severely damaged. When thoroughly dormant, the trees have been known to stand temperatures as low as 15° Fahrenheit without visible damage when the trees were in a healthy condition. However, this is getting to a dangerously low point for tung trees, and orchards should be located where there is little

likelihood of such temperatures being reached except at very rare intervals and for very short periods of time. In this connection, location of the orchard on gently sloping ground with adequate air drainage is of considerable value in assisting the trees to survive occasional low temperatures, since the cold air can drain away from the trees quickly. Numerous instances of apparent cold damage were observed in air-pocket locations where some obstacle, such as a hill or heavy pine wood bordered the grove and formed a natural barrier to the flow of cold air away from the orchard.

There should be adequate rainfall of not less than 40 inches, and preferably 50 inches or more, well distributed over the season.

Next to the climatic requirements there is no more critical factor in the successful development of a tung orchard than that of the proper selection of soil. Because of the high degree of variability in soil series and types in this southern area, it would be well for anyone contemplating going into tung production to employ the services of a qualified agronomist or other person competent through training and experience to differentiate between soil types and to select those locations which would be well adapted to tung. In general, experienced growers and research workers alike agree that soil suitable for tung is soil which is well adapted to a variety of crops. It should be a well-drained sandy loam or fine sandy loam underlain at a depth of 3 to 8 feet by a friable, porous clay subsoil. It should be slightly on the acid side with a pH of 5 to 6.8 (with 7 as neutral). The soil should have a satisfactory moisture and nutrient-holding capacity. In general, fine sandy loam or sandy loam with friable clay subsoil which can be classified in the following series, will be found suitable if it meets the requirements stated above:

Orangeburg	Tifton
Ruston	Faceful
Norfolk	Magnolia
Red Bay	Greenville
Marlboro	Gainesville

and possibly Arrendondo and Ora. Generally unsuitable are deep Norfolk sand and Susquehanna and Bladen clays, and soils of the Leon, Caddo, and Coxville series. Any of these soils may prove to have certain minor deficiencies of zinc, manganese, or iron, as may be indicated by the development of certain characteristic symptoms in the appearance of the trees and leaves. Such soil deficiencies are relatively easily corrected by the application of minor amounts of chemicals as recommended by the tung oil research laboratories.

Tung trees may be started by the planting of seed in place in the orchard where it is wanted to grow, or by the transplantation of nursery stock grown from seed planted in rows in the nursery, usually for 1 year though occasionally nursery stock is used until it is 4 or 5 years old (the latter not recommended). Use of a nursery permits the selection of the

more vigorous trees and the discarding of the off-type and weakling trees. The tops should be cut back rather severely at time of transplanting to compensate for the loss of a certain amount of the roots and to encourage the development of a strong central trunk. There are some growers who vigorously insist that seed planted in place produces the better trees, provided only that additional and more expensive care be given the trees to keep down weeds and give the trees a chance to develop properly. In either case the selection of seed to be used for planting is important. To a limited extent at present, and to a far greater extent probably in the future, the grower can obtain seed from trees of known high-producing record and with the ability to transmit this high production.

With the possible exclusion of Florida, the use of budded stock appears to have very promising possibilities for the vegetative propagation of the trees. There appears to be general agreement that the use of budded stock, under favorable conditions, is the most certain way to obtain an orchard of uniform characteristics, similar to the parent tree or trees.

Very early in the history of tung development in the United States there was an unfortunate but passing phase of so-called "strip planting." In this process just enough ground was cleared in the tree row to make a place to plant seed or set out trees. In many instances no other care was given for a period of several years, and as a consequence a very high proportion of such plantings was completely unsuccessful. Now, however, most growers are thoroughly agreed that the ground should be completely cleared from tree row to tree row and cultivated enough to keep down weeds during the early years.

Tung trees should be located in rows parallel to the contours and terraces. Terracing should be practiced wherever the slope is such that any appreciable surface erosion might occur. A wide variety of planting distances has been used in the past; most of these were too short, resulting in the trees crowding each other early in their productive life. It is now rather generally agreed that spacing should not be less than the equivalent of 20 x 30 feet, with the wider distances being between the rows, and the shorter distance between the trees within the rows. Setting the trees 20 x 30 feet would result in an orchard with about 72 trees to the acre. Some authorities advocate an even wider planting with as few as 50 trees to the acre. At the same time it is hard to condemn growers who plant up to 100 trees per acre for the reason that it will be perhaps 10 or 15 years before the trees have fully occupied the space and start crowding each other seriously; in the meantime, of course, they will be producing several crops. The logical alternative of planting close and later cutting out every other tree seldom works in practice since the growers never seem to find the time ripe for cutting out the alternate trees.

Temperature and rainfall conditions in the tung area have produced soils which in general require considerable attention to a fertilizer and cover-crop program, to maintain an adequate amount of humus and fertility in the soil.

A winter cover crop of Austrian peas, vetch or one of the Lupines is recommended in all cases. Also, unless prevented by the excessive shading of fully grown trees, or by a shortage of labor, a summer cover crop is strongly recommended. One of the best of the summer cover crops is Crotalaria spectabilis, which when turned under in the proper green stage returns a considerable amount of humus and nitrogen to the soil. Unfortunately this particular Crotalaria is fatal to livestock, and if the tung orchard is not fenced it may be better to use Crotalaria intermedia. Both the trees and the cover crop should receive some fertilizer in accordance with the requirements of the soil. It has been suggested that a good mixed fertilizer of an approximate formula 5-7-5 be used for the trees in the approximate ratio of one-half to three-quarters of a pound per tree while the trees are nonbearing and at the rate of one pound per year of age per tree thereafter. For young trees it may be worth while to scatter this fertilizer within the area shaded by the tops of the trees, but for older orchards it probably is sufficient just to broadcast it.

Fertilizer for the cover crop can well be applied to the land about the same time that the cover crop is sown and disked under at the same time. Nitrate or sulphate of potash is generally recommended at the rate of 50 to 150 pounds per acre. Dolomitic limestone or basic slag should be applied at the rate of 300 to 500 pounds per acre. The use of superphosphate up to the amount of 150 pounds to the acre may be advisable in some instances.

In addition to these commercial fertilizers it has been reported that the fertilizer value of the tung meal residue from the crushing operation is somewhere in the neighborhood of $20 to $30 per ton of meal at 1941-42 prices and well worth the effort and expense required to haul it back to the orchards and scatter it. Tung meal can take the place of part of the commercial fertilizer.[1] The value of the tung hulls is less, being estimated at a value of from $1 to $2 per ton. Because of its potash content it is probable that it would pay to haul these hulls back to the orchard also.

With two cover crops a year, at least two thorough diskings will be required each year to turn under the green material. The diskings should not be too deep so as to avoid injuring the myriad feeder roots of the tung trees which quite closely approach the surface. Other than turning under the cover crop, the principal object of disking is to control weeds and so prevent competition with the tung trees for soil nutrients and mositure. Even the summer cover crop itself should be cut on each side of the trees in particularly dry seasons, if the cover crop appears to compete severely with the trees for water.

[1]Tung meal analyzes approximately 4 to 6 percent nitrogen, 1 to 2 percent phosphoric acid, and 1.2 to 1.4 percent potash. Hulls contain about three-fourths of 1 percent nitrogen, less than one-half of 1 percent phosphoric acid, and 3 percent potash.

While some differences of opinion still exist with respect to pruning, it is most generally accepted that mature tung trees require only occasional pruning to remove dead branches and any shoots or sprouts which happen to interfere with the tools used in machine cultivation. Some guidance can be given to the young trees by pruning to obtain a shape which will later hold a heavy load of fruit without splitting. Particularly to be avoided is a cartwheel type whorl.

Opinions as to the advisability of combining livestock with tung are varied. The most reasonable view appears to be that no livestock whatever should be permitted in the orchards while the trees are young. There may be a limited place for livestock in mature orchards for such portion of the year as the natural weed growth and cover crop would provide some pasturage. Such a program would require a considerable amount of other lands in addition to the tung orchard to provide pasture at times when the tung area would not provide enough pasturage and for the period in the fall when the stock could not be allowed in the orchard for fear of trampling the nuts into the ground as they fall.

Harvesting offers no particular problems except, perhaps, the provision of cheap labor. After the nuts mature in the early fall, they generally fall to the ground of their own accord within a very short period and should be allowed to remain there for several weeks. When the nuts are dried by the sun and air to a fairly uniform degree they are picked up by crews, usually women or children, on a piece work basis at 5 or 10 cents a sack. While the period within which the nuts must be crushed is not at all critical, the nuts usually are not dry enough for processing before late January or early February, and under present storage conditions should be crushed probably before June. If the nuts are held in ordinary farm storage beyond that time, there appears to be a decline in the amount of oil recoverable. The nuts are generally stored on the farm either in sheltered piles of bags or, more recently, in well ventilated bins built somewhat on the corncrib plan.

At the mill the nuts are first put through a decorticator which removes the hull. The shells surrounding the kernels are also broken and the hulls and about half of the shells are removed before the kernels are ground. Presses generally used in the tung area are of the Anderson expeller type, having a broken screw-type press revolving inside of a cylinder of bars. Excessive moisture in the nuts when delivered to the mill is probably the chief cause of difficulty to the mill operator. The moisture content should not be over about 13 percent of the total weight of the nut, but mills commonly accept many nuts from the growers that run as high in moisture as 14 or 15 percent of the weight of the whole tung fruit.

Roughly half the weight is in the hull, 20 percent in the shells, and 30 percent in the kernels. While laboratory analysis of the total oil content of the nut might run from 21 to 25 percent, actually under mill-run conditions the expellers have been obtaining about 16 percent of the total weight of the tung fruit as oil. The development of solvent extraction plants would, of course, raise the percentage recoverable.

As of December 1942 there were three tung oil mills operating in Louisiana, with a combined capacity of approximately 34 tons per day; three tung mills in Mississippi with a combined capacity of about 48 or 49 tons per day; and four active mills serving Alabama, Georgia, and Florida with a combined capacity of 82 tons per day. A number of the mill operators look forward to the time when production from their own orchards would occupy the dominant portion or entire amount of their mill capacity. As more tung orchards come into bearing, additional milling capacity will need to be provided and it is in this connection that a cooperative organization might be of considerable service to the tung growers. One of the Louisiana mills is a cooperative association which has been operating successfully and in a manner which returns the largest possible returns to the tung growers.

Some mill operators have been keeping the tung meal and hulls for use on the miller's orchards, while others have urged the growers to haul this residue back to the orchards from which the nuts came. Some mills reported an active demand for tung meal and hulls for use by companies manufacturing mixed fertilizers.

The latest United States farm census shows a total of 2,304 farms reporting tung trees. These farms, located in eight States, reported a total of 12,671,344 tung trees, which at the rate of 70 trees per acre would be approximately 182,000 acres, as of January 1, 1940. Nonbearing trees in relation to bearing trees are in a ratio of more than 2 to 1. Reports indicated 4,114,555 trees of bearing age. The 498 farms which reported their tung production in the crop year 1939 had a crop of 2,321,139 pounds. Estimates from other sources indicate a total United States crop of tung nuts for 1938 and for 1940 of at least 25,000,000 pounds. These figures indicate a very low production for the industry as a whole, due in part to the immaturity of the trees, in part to the lack of selection for high-producing strains in past plantings, and to other factors, such as poor selection of soil. Government experiment laboratories have done preliminary work which indicates a possibility of a much higher average yield for the industry in the years to come. With soil and climatic conditions favorable, it should not be at all impossible for the better growers to average about three-quarters of a ton per acre on their best orchards from plantings already established. With the introduction of uniform, selected strains, production may go considerably above this.

Mississippi is the leading State in total number of trees, with more than four times the number of Louisiana, its nearest competitor. Florida which was once the primary State is now in third place with Alabama and Georgia coming next. Texas has an appreciable number of trees, while California and South Carolina have only a very few trees.

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